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1 Safety in the Laboratory

Students share the role when ensuring that science activities are conducted in a safe and responsible manner. This section deals with actions you can take to help promote your own personal safety and the safety of others during lab activities.

Before Starting This Course

1) Inform your teacher of any health concerns and circumstances that may affect your personal safety, such as allergies, medication you are currently taking, whether you wear contact lenses, and any medical or physical condition that may affect your ability to participate.

2) Familiarize yourself with the lab you will use. Your teacher may ask you to draw a map of the lab and to indicate the location of various safety equipment, including lab aprons, safety glasses, protective gloves, eyewash stations, fire extinguishers, fire blankets, fire alarms, first-aid kit(s), chemical-spill kit(s), the chemical disposal area, and the broken glass disposal. Your teacher may also ask you to label other important areas in the room. At the bottom of your map, indicate the location of the nearest exit—in the event of a fire—from the lab and the building.

Before Each Activity

1) For days when you know you will be doing a lab activity, arrive appropriately dressed. For example, wear close-toed shoes, no loose clothing, and no dangling jewellery. Also, if applicable, tie your hair back.

2) Learn about the hazards posed by the materials and equipment you will be using in the activity. If your teacher asks you to read over the activity the day before, remember to do so! Read the activity not only for what you will do, but for what it instructs you not to do, and for other safety concerns. Pay particular attention to WHMIS symbols and other safety information.

3) Only take the materials you will need (e.g., textbook, laboratory instruction sheet, paper, pencil or pen, calculator) into the lab.

4) Listen carefully to your teacher's instructions. If you do not understand how to perform a step, ask for clarification.

5) Ensure that you understand the safety precautions associated with the procedure of the activity and what to do in the event of an accident.

6) Obtain your teacher's approval before starting any activity or investigation you designed yourself.

7) Wear safety glasses and a lab apron, and ensure that you have all other safety equipment required for an activity before proceeding.

During the Activity

1) In the event of a chemical spill (or any other unsafe situation), immediately report the situation to your teacher.

2) Dispose of all chemicals, specimens, and other materials in the manner instructed by your teacher.

3) Follow all instructions and safety procedures. When manipulating equipment and materials, do so in a way that shows concern for your own safety and the safety of others in the lab.

4) If you are uncertain about an issue involving safety, ask your teacher for clarification.

5) Do not eat or drink while in the laboratory.

6) Use only the amount of material needed to complete the activity. Taking additional chemicals does not increase the accuracy of your efforts; it only increases the amount of waste.

7) Do not taste or draw materials into your mouth (e.g., mouth pipetting).

8) Use two hands to carry lab equipment. One hand should always be used to support the piece from the bottom.

9) If any part of your body comes into contact with a chemical, immediately inform your teacher. Quickly and thoroughly wash the contacted skin with water. In the event that chemicals get into your eyes, immediately flush your eyes with water for a minimum of 15 minutes.

At the End of Each Activity

1) Ensure that all materials and equipment are cleaned and returned to their proper place in the laboratory.

2) Place all chemical wastes into the appropriate containers or disposal areas in the lab as instructed by your teacher.

3) Ensure that you have cleaned your workstation by checking the tabletop, shelves, drawers, and floor.

4) Report any problems regarding broken, cracked, chipped, or unsafe equipment to your teacher.

5) Return lab aprons and safety glasses to their proper places.

6) Wash your hands thoroughly before leaving the lab.

2 WHMIS

Workplace Hazardous Materials Information System

Every day, through daily routines, people are exposed to materials that may be potentially harmful. To communicate information about the possible risk associated with the use of these materials and to convey information regarding proper methods for their use, the WHMIS system was developed. Eight symbols are used to depict the hazard classes in this system. For each symbol, a brief description of the materials, the possible risks associated with the materials, and the safety considerations regarding the handling and storage of these materials are given. It is possible for some substances to be categorized into more than one WHMIS category. For such substances, both sets of safety considerations should receive attention.

Class A: Compressed Gas

Description: compressed pure gases (e.g., helium and oxygen), dissolved gases (e.g., aqueous carbon dioxide), and gases liquified when compressed or refrigerated (e.g., propane)
Possible Risks: Containers may explode if heated or dropped.
Safety Considerations: Handle containers with care, ensuring not to drop or place them in a manner that they can be easily upset. Keep containers away from sources of heat and from substances that may ignite.

Class B: Flammable and Combustible Material

Description: solids, liquids, or gases capable of catching fire or exploding in the presence of a source of ignition (e.g., ethanol, propane, and group 1 metals like sodium and potassium) **Note:** Flammable materials are defined as materials that may be easily ignited or are capable of burning readily. Combustible materials are defined as substances that may burn, but do not readily ignite.
Possible Risks: These substances will burn and, therefore, are a potential fire hazard. Flammable materials will burn at low temperatures. Some substances may spontaneously burst into flames in air or may release a flammable gas when coming into contact with water.
Safety Considerations: Keep these materials away from sources of heat, sparks, or flames. Some materials must be stored in special containers to prevent exposure to air or water.

Class C: Oxidizing Material

Description: substances that provide oxygen when they react (e.g., hydrogen peroxide and sodium hypochlorite) **Note:** The production of oxygen increases the risk of fire if the substances contact Class B materials.
Possible Risks: These materials may ignite or explode if they come into contact with flammable or combustible materials. These materials may burn skin or eyes upon contact.
Safety Considerations: Wear proper protective equipment, including eye, face, and hand protection. Keep these substances away from sources of ignition and combustible materials. Store these materials in appropriate containers.

Class D: Poisonous and Infectious Material

Division 1: Materials Causing Immediate and Serious Toxic Effects

Description: materials that can cause the death of a person if exposed to small amounts
Possible Risks: These materials may result in death or serious harm, even if exposed to small amounts of the substance, and may enter the body by inhalation, ingestion, or through the skin.
Safety Considerations: Handle these materials with extreme caution. Avoid contact with eyes and skin, and avoid inhalation. Wear safety glasses, a face shield, and gloves; and work in well-ventilated areas. Store materials in proper containers and in appropriate areas. Wash thoroughly after handling these materials.

Class D: Poisonous and Infectious Material

Division 2: Materials Causing Other Toxic Effects

Description: exposure does not result in immediate effects, but may result in long-term effects to individuals who are repeatedly exposed to these materials in small amounts (e.g., asbestos, acetone, and chromium oxide)
Possible Risks: These materials may be poisonous in the long term if repeatedly exposed. They may irritate skin or eyes, may cause chemical sensitivities, allergies, cancer, and/or result in birth defects.
Safety Considerations: Avoid contact with skin by wearing proper protection for eyes and skin. Avoid inhalation by working in well-ventilated areas or by using appropriate respiratory equipment. Store in proper containers.

Class D: Poisonous and Infectious Material

Division 3: Biohazardous Infectious Material

Description: harmful micro-organisms including bacteria, fungi, and viruses
Possible Risks: These micro-organisms may infect other organisms and cause illness or disease.
Safety Considerations: Handle material only in appropriate areas (can be sterilized) with appropriate techniques (e.g., aseptic technique) and equipment (e.g., biosafety hoods) to avoid contamination.

Class E: Corrosive Material

Description: materials that can destroy the skin and/or eat through metals [e.g., acids and caustic (basic) substances]
Possible Risks: These materials can cause severe irritation to eyes or skin upon contact. If there is prolonged contact, more serious tissue damage can result. These materials may be harmful if inhaled.
Safety Considerations: Keep materials in tightly sealed containers. Avoid contact with skin and eyes by using appropriate protection. Avoid inhalation by working in well-ventilated areas.

Class F: Dangerously Reactive Material

Description: materials that can undergo reaction when subjected to heat, pressure, and shock or when allowed to contact water [e.g., butadiene (plastic monomer) and group I metals like sodium and potassium]
Possible Risks: These materials may explode or release toxic or flammable gases when they react.
Safety Considerations: Store in a cool, flame-proof area. Exercise extreme caution when moving and opening containers.

3 SI and Non-SI Units

SI Units

Units play an important role in the communication of numerical information. The system of units used in science is called SI (Système International d'Unités). It consists of seven base units. Refer to the Quantities and Base Units in SI table.

QUANTITIES AND BASE UNITS IN SI

Quantity Name	Symbol for Quantity	Unit Name	Symbol for Unit
length	l	metre	m
time	t	second	s
mass	m	kilogram	kg
amount of substance	n	mole	mol
temperature	T	kelvin	K
electric current	I	ampere	A
luminous intensity	I_v	candela	cd

These quantities can be combined to form derived units. The derived units you will encounter in this Science 20 course are summarized in the Derived Quantities and Their Units in SI table.

DERIVED QUANTITIES AND THEIR UNITS IN SI

Quantity Name	Symbol for Quantity	Unit Name	Symbol for Unit
area	A	square metre	m^2
volume	V	cubic metre	m^3
molar mass	M	grams per mole	g/mol
molar concentration	C	moles per litre	mol/L
pressure	p	pascal	pa
force	F	newton	N
energy	E	joule	J
work	W	joule	J
power	P	watt	W
speed	v	metres per second	m/s
acceleration	a	metres per second per second	m/s^2
momentum	p	kilograms metres per second	kg·m/s
impulse	impulse	newton second	N·s

SI is the communication and measurement system used by scientists worldwide. It is also the official system of measurement used in most countries, including Canada. Part of the reason for its widespread use is the convenience it provides through the use of prefixes. Prefixes change the size of units by powers of ten (as shown on the following table).

Prefix	Symbol	Factor by Which Base Unit Is Multiplied
tera	T	$1\ 000\ 000\ 000\ 000 = 10^{12}$
giga	G	$1\ 000\ 000\ 000 = 10^{9}$
mega	M	$1\ 000\ 000 = 10^{6}$
kilo	k	$1000 = 10^{3}$
hecto	h	$100 = 10^{2}$
deca	da	$10 = 10^{1}$
deci	d	$0.1 = 10^{-1}$
centi	c	$0.01 = 10^{-2}$
milli	m	$0.001 = 10^{-3}$
micro	μ	$0.000\ 001 = 10^{-6}$
nano	n	$0.000\ 000\ 001 = 10^{-9}$
pico	p	$0.000\ 000\ 000\ 001 = 10^{-12}$

As you can see, the powers of ten are convenient because they eliminate the need for so many zeros as place holders. The prefixes are a further refinement because they make communication even more concise.

Examples of the use of SI prefixes are as follows:

- 3 000 000 000 joules = 3 ¥ $\mathbf{10^{9}}$ joules = 3 **giga**joules = 3 GJ
- 2400 metres = 2.4 ¥ $\mathbf{10^{3}}$ metres = 2.4 **kilo**metres = 2.4 km
- 0.854 seconds = 854 ¥ $\mathbf{10^{-3}}$ seconds = 854 **milli**seconds = 854 ms

Non-SI Units

Other units that are not part of SI are often used in science. Examples of these units are summarized in the following table.

Quantity Name	Unit Name	Symbol	Definition
area	hectare	ha	1 ha = 100 m ¥ 100 m = 10 000 m^2
volume	litre	L	1 L = 1000 cm^3
mass	tonne	t	1 t = 1000 kg
temperature	Celsius	°C	0°C = 273.2 K
time	minute	min	1 min = 60 s
	hour	h	1 h = 60 min = 3600 s
	day	d	1 d = 24 h = 86 400 s
	year	a	1 a = 365.25 d = 31 557 600 s

4 Conversion Factors

A conversion factor is simply a fraction that converts one unit into another. Problem solving often involves converting one set of units into another. This is best done in the solution of the problem where the knowns and unknowns are listed. As the examples that follow illustrate, a conversion factor provides a systematic way of converting units.

Example Problem 1

Convert $\Delta t = 2.250$ h into seconds.

Solution

This example involves converting hours into seconds; so, the fraction will be based upon 1 h = 3600 s. The conversion factor is equal to 1. Since multiplying by 1 does not make a quantity larger or smaller, multiplying the time interval by the conversion factor does not make the time interval larger or smaller—only the units change.

For hours to cancel out and the value to be in seconds, set up the conversion factor so hours is in the denominator and seconds is in the numerator.

$$\frac{3600\ \text{s}}{1\ \text{h}}$$

Now, multiply the time interval by the conversion factor to convert hours into seconds.

$$\Delta t = 2.250\ \cancel{\text{h}} \cdot \frac{3600\ \text{s}}{1\ \cancel{\text{h}}}$$

$$= 8100\ \text{s}$$

Example Problem 2

Convert $m = 3452$ g into kilograms.

Solution

1000 g = 1 kg

Set up the conversion factor so grams is in the denominator and kilograms is in the numerator.

$$\frac{1\ \text{kg}}{1000\ \text{g}}$$

Now, multiply the mass by the conversion factor to convert grams into kilograms.

$$m = 3452\ \cancel{\text{g}} \cdot \frac{1\ \text{kg}}{1000\ \cancel{\text{g}}}$$

$$= 3.452\ \text{kg}$$

Example Problem 3

Convert $v = 2.65$ m/s into kilometres per hour (km/h).

Solution

1000 m = 1 km and 3600 s = 1 h

To convert metres into kilometres, set up a conversion factor with metres in the denominator and kilometres in the numerator.

$$\frac{1\ \text{km}}{1000\ \text{m}}$$

To convert seconds into hours, set up a conversion factor with seconds in the numerator and hours in the denominator. Note that because seconds is in the denominator of the original quantity, it must be in the numerator of the conversion factor for cancellation to occur.

$$\frac{3600\ \text{s}}{1\ \text{h}}$$

Now, multiply the speed by the conversion factors to convert metres per second (m/s) into kilometres per hour (km/h)

$$v = 2.65\ \frac{\cancel{\text{m}}}{\cancel{\text{s}}} \cdot \frac{1\ \text{km}}{1000\ \cancel{\text{m}}} \cdot \frac{3600\ \cancel{\text{s}}}{1\ \text{h}}$$

$$= 9.54\ \frac{\text{km}}{\text{h}} \text{ or } 9.54\ \text{km/h}$$

5 Measurements and Significant Digits

Numerical information is communicated in terms of exact values and measurements. Exact values can represent defined quantities or quantities that are counted. Measurements involve taking a reading from a measuring instrument.

EXAMPLES OF NUMERICAL INFORMATION

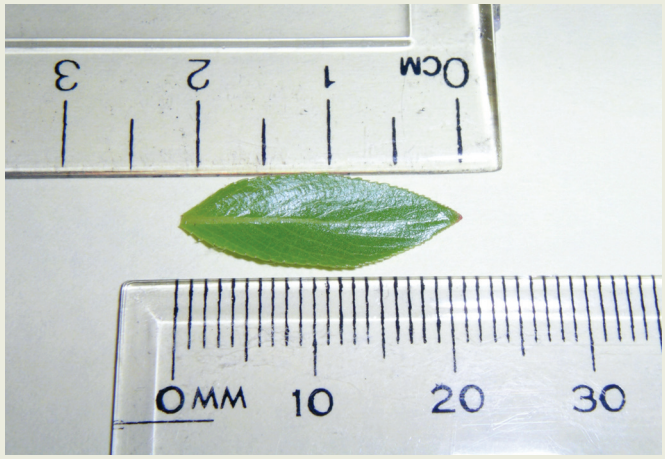
Exact Values	Measurements
• 1 h = 3600 s • 5 of the 10 seeds germinated.	• 37.64 g of NaCl • The marble rolled 16.7 cm.

Accuracy and Precision

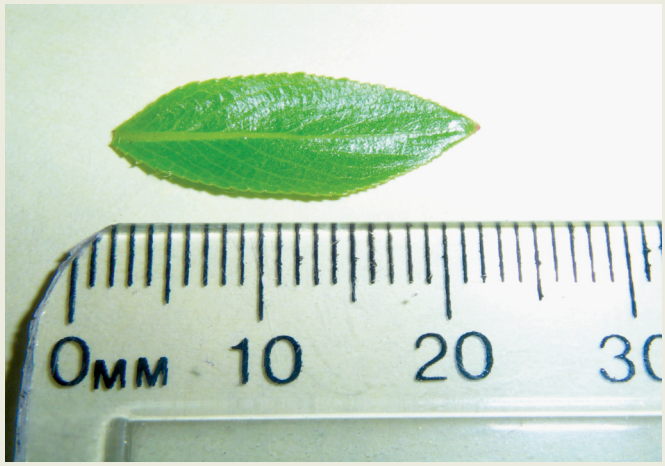
Since measurements always involve taking a reading from a measuring instrument, all measured quantities have some degree of uncertainty. The source of this uncertainty has to do with the two types of measurement errors:

1) Errors can occur when the person reading the instrument has to estimate the last digit of the measurement. The size of this kind of error has to do with the precision of the measuring instrument. Using the ruler at the top of the upper photo, the leaf would measure 2.1 cm or 2.2 cm. Because the markings on this ruler are 0.5 cm apart, the first digit past the decimal must be estimated.

The ruler on the bottom of the upper photo has greater precision because the markings on this ruler are 0.1 cm or 1.0 mm apart. A measurement of the same leaf with this ruler suggests that the length of the leaf could be 21.0 mm, 21.1 mm, or 21.2 mm.



2) Errors can also occur due to inherent problems with the measuring system. The bottom photo shows the same leaf measured with a ruler that has a rounded end. Although this ruler is just as precise as the one at the bottom of the top photo, it is not as accurate. In this case the leaf appears to have a length of 22.2 mm.



Significant Digits

If a leaf is measured to be 21 mm long, it is said to have two significant digits. The last digit is the uncertain or estimated digit. Because this same leaf can be expressed in a number of units, it is important that the precision of the measurement does not change with the choice of units, since the precision is determined by the measuring instrument that made the original measurement. All of the following measurements describe the same leaf, and all of these measurements have two significant digits:

length of leaf = 21 mm = 2.1 cm = 0.021 m = 2.1×10^4 µm

Notice that the zeros in front of the value in metres are not significant. These zeros are simply serving as place holders.

Suppose a different ruler is used and the length of the leaf is measured with greater precision. How many significant digits are there in each of the following measurements?

length of leaf = 21.1 mm = 2.11 cm = 0.0211 m = 2.11×10^4 µm

Each of these measurements has three significant digits.

Calculations with Significant Digits

Rounding

Expressing calculated values to the correct number of significant digits requires skills in rounding. There are only two rules to rounding:

1) If the first digit to be dropped is 0, 1, 2, 3, or 4, the digit preceding it does not change. For example, to round 6.2547 to three significant digits, look at the fourth digit. Since the digit to be dropped is 4, this value is rounded to 6.25.

2) If the first digit to be dropped is 5, 6, 7, 8, or 9, the digit preceding it increases by 1. For example, to round 6.2547 to two significant digits, look at the third digit. Since the digit to be dropped is 5, this value is rounded to 6.3.

Exact Values

All exact values have an infinite number of significant digits. Recall that exact values represent defined quantities or quantities that are counted. For example, consider the statement, "5 of 10 seeds germinated." Because the number of seeds germinated is counted and, therefore, considered to be exactly known, the value 5 has an infinite number of signficant digits.

Conversion factors, like $\frac{3600\ \text{s}}{1\ \text{h}}$ and $\frac{1\ \text{km}}{1000\ \text{m}}$, are also considered to be exact values. Because conversion factors are considered to be exactly known, they, too, have an infinite number of significant digits. Therefore, when you convert a measurement, the converted measurement must have the same number of signficant digits as the original measurement.

Example Problem 4

Convert 1.50 h into seconds.

Solution

There are 3600 s in 1 h.

$$1.50\ \cancel{\text{h}} \times \frac{3600\ \text{s}}{1\ \cancel{\text{h}}} = 5.40 \times 10^3\ \text{s}$$ ¬ 3 significant digits

Adding and Subtracting

When adding and subtracting values of varying precision, first carry out the operation without rounding any of the values. Then round the final answer to the same precision as the least precise value.

Example Problem 5

Four students each measured a different leaf from the same plant. The data is summarized in the following table.

Student	A	B	C	D
Length of Leaf (cm)	2.2	2.59	2.98	2.5

Use this data to determine the total length if all four leaves are placed end to end.

Solution

Students A and D were only able to measure their leaves to the nearest tenth of a centimetre. These two measurements are the least precise. Therefore, the final answer must be rounded to the nearest tenth of a centimetre.

$$\begin{aligned}\text{Total length} &= 2.2\text{ cm} + 2.59\text{ cm} + 2.98\text{ cm} + 2.5\text{ cm} \\ &= 10.27\text{ cm} \\ &= 10.3\text{ cm}\end{aligned}$$

The total length of the four leaves is 10.3 cm.

Multiplying and Dividing

When multiplying values with varying numbers of significant digits, first carry out the operation. Then round your final answer to the least number of significant digits in the original values.

Example Problem 6

Four teams of students are attempting to calculate the average speed of a person on inline skates at the local skate park. Here is the data they collected.

Team	Distance Between Pylons Dd (m)	Time Dt (s)
A	8	3.7
B	8.2	3.8
C	8.3	3.76
D	8.28	3.77

Determine the average speed, v, for each team.

Solution

Team A

$$v = \frac{\Delta d}{\Delta t}$$
$$= \frac{8\ \text{m}}{3.7\ \text{s}}$$
$$= 2\ \text{m/s}$$

Team B

$$v = \frac{\Delta d}{\Delta t}$$
$$= \frac{8.2\ \text{m}}{3.8\ \text{s}}$$
$$= 2.2\ \text{m/s}$$

Team C

$$v = \frac{\Delta d}{\Delta t}$$
$$= \frac{8.3\ \text{m}}{3.76\ \text{s}}$$
$$= 2.2\ \text{m/s}$$

Team D

$$v = \frac{\Delta d}{\Delta t}$$
$$= \frac{8.28\ \text{m}}{3.77\ \text{s}}$$
$$= 2.20\ \text{m/s}$$

Because Team A's distance is measured to only one significant digit, the calculation of average speed must be rounded to one significant digit.

Team B's measures of distance and time consist of two significant digits. Therefore, the calculation of average speed is rounded to two significant digits.

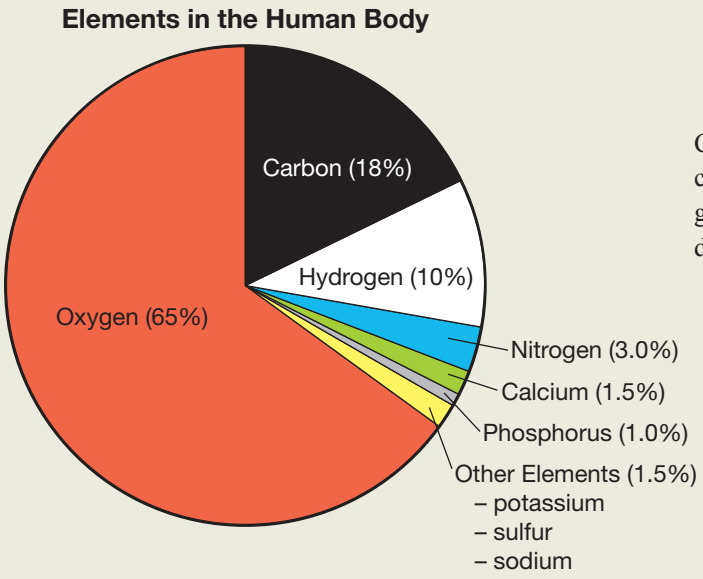
Although Team C was able to improve the degree of precision in measuring time, the measure for distance consists of only two significant digits. Therefore, the calculation of average speed must be rounded to two significant digits.

Team D's measures of distance and time each consist of three significant digits. Therefore, the calculation of average speed is rounded to three significant digits.

6 Graphing Skills and Graphical Analysis

You will see a number of different types of graphs as you work through this course. As the following examples indicate, graphs should always include a title.

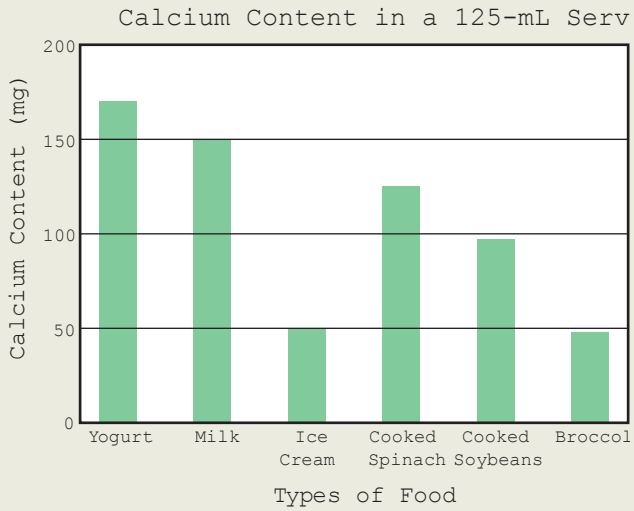
Circle Graphs



Circle graphs, sometimes called pie charts, show the contributions of different categories to the whole. Circle graphs are most helpful when you want to efficiently display the distribution of the data.

Bar Graphs

A bar graph is more flexible than a circle graph because a bar graph can compare the effect of a specific variable within a particular category. Each category—in this case the type of food—becomes the manipulated variable, and the value being compared—in this case calcium content—is the responding variable. It is important for both axes to be labelled and for each of the bars to be the same width.



Scatterplots

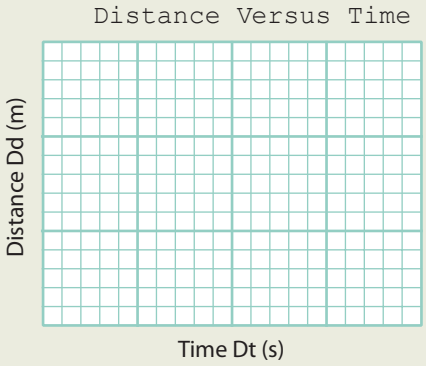
Scatterplots are most useful when both the manipulated and responding variables are changing throughout the experiment. Consider the following data, which was collected by a group of students studying the motion of a remote-controlled car moving through an empty parking lot. The students recorded the position of the car every 1.0 s as it moved along a measuring tape.

Time (s)	1.0	2.0	3.0	4.0	5.0	6.0
Distance (m)	9.0	11.9	14.5	18.5	19.8	23.5

How to Produce a Scatterplot from Sample Data

Step 1: Labelling

Place the manipulated variable on the horizontal axis (x-axis) and the responding variable on the vertical axis (y-axis). Make sure you include units in the label.

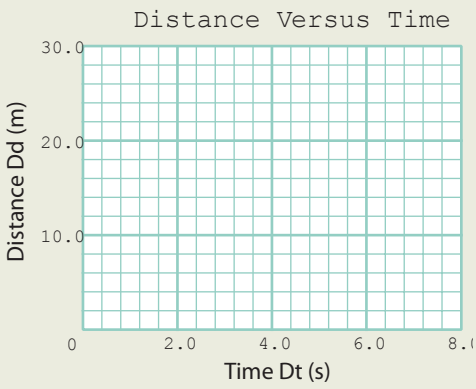


One way to remember which variable goes on each axis is to think back to methods of graphing presented in previous math courses. Previously, you had set up a table of values in which you selected a number of x-values. You then determined the corresponding y-values from an equation. Similarly, in this experiment, the students defined the time intervals before starting the experiment, making time the manipulated varible (x-axis). The students then determined the corresponding distances, making distance the responding variable (y-value).

Once you have labelled the axes, title your graph. One common format to follow is "Responding Variable Versus Manipulated Variable."

Step 2: Scaling the Axes

Choose a scale that is convenient and that uses as much of the available space as possible.

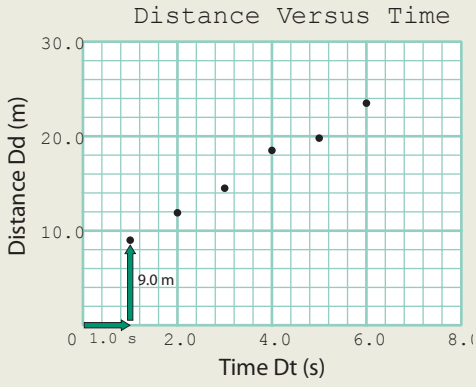


The values for time range from 1.0 s to 6.0 s. When determining an appropriate scale, the range should go beyond the range of the data. For this grid, the time data can be spread over 20 gridlines. So, an appropriate scale would be 2.0 s every five gridlines. This will provide a range of 0 s to 8.0 s.

The values for distance range from 9.0 m to 23.5 m. When determining an appropriate scale, the range should go beyond the range of the data. For this grid, the distance can be spread over 15 gridlines. So, an appropriate scale would be 10 m every five gridlines. This will provide a range of 0 m to 30 m.

Step 3: Plotting the Data

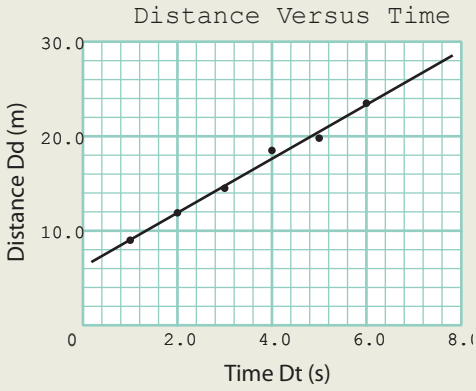
Each pair of values represents a point on the graph. Plot each point by moving along the horizontal axis to the specified time value and then up to the corresponding distance value.



For example, to plot the first point of the students' data, move along the horizontal axis until you get to $t = 1.0$ s; then move straight up until you get to $d = 9.0$ m.

Step 4: Drawing a Best-Fit Line or Curve

Data points usually do not line up perfectly due to experimental error. So, a best-fit line or curve is needed to show a trend (if one appears) in the data.



If the trend is a straight line, use a ruler. If the trend is a curved line, draw a smooth curve that best represents the trend of the data. **Do not draw a jagged line by simply connecting the points, and do not force the best-fit line or curve through the origin.** The line should be drawn so that there are the same number of data points slightly above and below the line. Remember, the best-fit line is an average.

In this example, the trend of the data can be best represented by a straight line.

How to Find the Slope of a Best-Fit Line

Data can be further summarized by determining the slope of the best-fit line. Recall that the formula for determining slope is

$$\text{slope} = \frac{\text{rise}}{\text{run}} = \frac{y_2 - y_1}{x_2 - x_1}$$

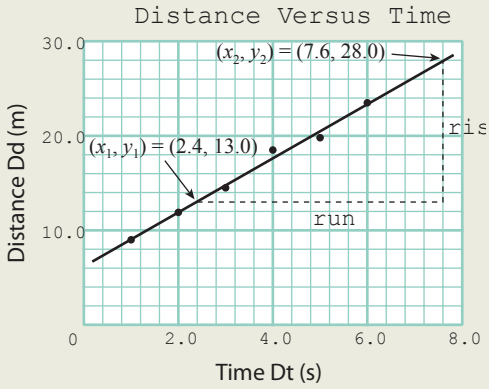
Slope is determined through a calculation involving measurements. Therefore, slope has a unit applied to it (e.g., m/s and km/h). Also, the rules of significant digits must be applied to the calculation of slope. Slope should be expressed with the same number of significant digits as the measurement in the original data with the least number of significant digits.

Follow these steps to determine slope. They involve using the data obtained by a group of students of the remote-controlled car.

step 1: Select two points on the best-fit line. Ideally, these points should be as far apart as possible, easy to read, and not a part of the original data.

step 2: Substitute the values, with units, into the slope equation, and calculate the slope.

$$\begin{aligned}\text{slope} &= \frac{\text{rise}}{\text{run}} \\ &= \frac{y_2 - y_1}{x_2 - x_1} \\ &= \frac{28.0\text{ m} - 13.0\text{ m}}{7.6\text{ s} - 2.4\text{ s}} \\ &= \frac{15.0\text{ m}}{5.2\text{ s}} \\ &= 2.9\text{ m/s}\end{aligned}$$



The slope of the data is 2.9 m/s.

7 Science Skills

The activities and investigations described in this textbook are designed to improve a variety of skills essential for all learners. Whether you are asked to critically read an article about an environmental issue, perform an experiment, use the Internet to find information on a topic, format a spreadsheet to make predictions, or prepare a presentation to communicate a message, you are using and further developing the skills associated with academic inquiry.

Alberta Education has divided science skills into four categories: initiating and planning, performing and recording, analyzing and interpreting, and communication and teamwork. Throughout this resource, science skill visual cues are shown along with each activity. When asked to complete an activity where any of these skills are identified, it may be helpful to refer to the Science Skills table to clarify what is expected.

SCIENCE SKILLS

Category	Description
Initiating and Planning	• Identify and state questions that could be investigated. These questions may arise from practical problems or from issues related to the application of science and technology. • Propose and assess alternative solutions to practical problems, and develop a plan to address them. • Design an experiment, identifying and controlling major variables. • State a prediction and a hypothesis based on available evidence, background information, or theories. • Evaluate, select, and develop a plan for the use of appropriate methods, procedures, and equipment for collecting evidence or information.
Performing and Recording	• Research, integrate, and synthesize information on a scientific question, practical problem, or technology from various print and electronic sources. Evaluate the strategy for the collection of information. • Select and use appropriate instruments for collecting data safely and accurately. • Carry out procedures in a manner to control variables or adapt and extend procedures where applicable. • Compile and organize findings and data by hand or computer using diagrams, tables, or graphs. • Apply WHMIS standards when handling and disposing materials used in experiments.
Analyzing and Interpreting	• Interpret patterns or trends in data using appropriate scientific terminology. • Estimate and calculate values. Compare empirical and theoretical values, and account for discrepancies. • Identify limitations of data and measurements, explain sources of error, and evaluate their importance to the overall result. Determine the reliability and adequacy of the data and the methods used to collect the data. • Identify new questions that arise from an investigation. • State a conclusion based on the data obtained. Explain how the evidence gathered supports or refutes the hypothesis, prediction, or theory. • Evaluate designs or technologies on the basis of criteria, including function, reliability, cost, safety, efficient use of materials, and impact on the environment. • Identify potential strengths and weaknesses (risks and benefits) of a solution to a problem based on the data collected. Use the analysis of the strengths and weaknesses (risks and benefits from a variety of perspectives) to recommend a possible course of action.
Communication and Teamwork	• Work co-operatively with others to develop and carry out investigations, troubleshoot problems, or develop prototypes. • Select appropriate numeric, symbolic, and graphical modes to communicate findings and conclusions. • Communicate in a persuasive and engaging manner using appropriate forms of multimedia. • Evaluate processes used both individually and as a group to complete the investigation.

8 Evaluating Sources of Information

You are bombarded with information on a daily basis. Whether you watch it on television, hear it on the radio, see it in a magazine or a newspaper, or find it on the Internet, the information you collect may not be authentic.

Research not only involves the collection of information; it also involves a careful analysis of the information collected. Can it be useful to you? Since your research usually includes finding information regarding a certain topic, you want this information to be credible, accurate, reasonable, and supported. The Criteria for Evaluating Sources of Information table may assist you in evaluating sources of information you collect; it may also help you improve not only the quality of your research, but your confidence in understanding and expressing your own ideas using the information.

CRITERIA FOR EVALUATING SOURCES OF INFORMATION

Criteria	Indicators That Source . . .	
	May Be Valuable	May Not Be Valuable
Credibility	• author knowledgeable and respected (Hint: Do a search using the author's name. See what other information he or she has published on the topic or what others have said about him or her.) • has been reviewed by others who are knowledgeable in the area (peer review)	• lists no author • has negative reviews regarding information • poor grammar and spelling
Accuracy	• includes up-to-date information as well as important historical information about the topic • provides a complete, well-rounded story (includes important facts, qualifications, and alternative explanations) • presents appropriate information for the type of research you are conducting	• lacks dates • descriptions vague • presents large generalizations • fails to mention recent information regarding topic • views expressed from only one (or very few) perspective • claims made that may not be supported by reasonable evidence
Reasonableness	• presents information in a thoughtful and balanced tone • presents and argues alternative opinions • presents believable information • contains no contradictions or gaps in logic	• terms indicating inappropriate criticism (e.g., How could any intelligent person not believe this?) • exaggerates (e.g., Join the thousands of satisfied customers.) • contains a conflict of interest (Authors of the information have a vested interest in swaying your opinion.)
Support	• data, values, or statistics from reliable sources • explains how data was collected • experiments used to collect data described and performed in appropriate scientific manner • information consistent with other information gathered from other sources • author describes information in a manner that you agree with	• presents statistics or data without identifying sources or how it was collected • lacks other sources that present or acknowledge information in the same manner

9 Internet Searching Skills

The Internet is a vast source of information on a variety of topics. Although it is extremely easy to find thousands of websites that contain information on a topic, there are often only a few that have the most relevant information you require and have time to read. There are a number of different tools, called search engines, available to assist you in finding information on the Internet. These engines organize and sort information by topic or key word. Alta Vista Canada (**www.altavista.com**), Google Canada (**www.google.ca**), and Yahoo! Canada (**www.yahoo.ca**) are just a few of the search engines available.

When using the Internet, there are two things to keep in mind:

1) **Do not believe everything you read.** The Internet is filled with information. Unfortunately, not all of it is correct. Anyone can put information on the Internet. The important thing is that you take a close look at the source to determine who is credited with supplying the information. The web address or URL—short for Uniform Resource Locator—can provide key pieces of information about the website that is supplying the information. As an example, a student searching the Internet for information related to the use of bicycle helmets was directed to the following site:

publisher: person or agency that operates server computer

www.med.ualberta.ca/acicr/download/bikesumm.pdf

folders and files: location of document

The first part of the URL, up to the first solitary forward slash, describes the "publisher"—the person or agency operating the server computer that is making this information available. In this case, the site is operated by the Faculty of Medicine and Dentistry at the University of Alberta. This indicates that the information is provided by a trustworthy source. The last part of the URL following the first solitary forward slash describes the specific folders and files for locating a particular document on this site.

As you examine the following three sites that could have resulted from the Internet search on bicycle safety, use the URL as an indicator of the trustworthiness or reliability of the information provided.

Canada Safety Council

www.safety-council.org/info/sport/helmets.html

non-profit organization

name of company selling bicycle helmets

www.extremehelmet.com/webspecials.html

normally a commercial organization

name of person

www.jimdata.com/~bicycle.html

indicates a personal web page

normally a commercial organization

Note: The last two sites are simply illustrations of possible sites.

The point is to use a critical eye and not believe everything you read. If you are uncertain about something, it is wise to double-check the information on one or two other sites or with other resources. For more information on assessing the credibility of information, read "Evaluating Sources of Information" on page 541.

2) **Websites can change or disappear.** You should keep in mind that the Internet is constantly changing. Sometimes you will discover that after typing in an address, a note will appear on the screen indicating that the site has moved or disappeared. If you find that an address does not work, you should go back to one of the search engines and do a general search using a key word or phrase.

Internet searching strategies can assist you in targeting your search toward finding relevant information and, then, refining your search to improve the relevance of the information you collect. They can be used to narrow (reduce), expand (increase), or identify connections (associations) between the websites identified during a search. The following table lists search operators (terms or keystrokes), their function, the expected result for your search, and the possible instance for its use. Use these strategies whenever you search for information on the Internet to increase the precision of your searches and your efficiency.

Operator	Description	Expected Result	Example
AND +	All terms joined by "AND" must appear in the document in any order.	• narrows a search • requires information on both search terms	• birds AND bioaccumulation • birds + bioaccumulation
OR	Either term joined by "OR" must appear in the document.	• expands a search • requires information on either search term	• bioaccumulation OR biomagnification
NOT AND NOT -	Documents that contain the term following "NOT" must be excluded from the document.	• narrows a search • helps locate specific information	• bioaccumulation NOT PCB • bioaccumulation AND NOT PCB • bioaccumulation-PCB
" "	The phrase inside the quotations must appear in the document.	• narrows a search • useful for phrases and associations between phrases	• "global warming" • "global warming" AND arctic • "global warming" AND "arctic food chains"
NEAR	The term following "NEAR" is to be within a certain number of words of the term in front of "NEAR."	• narrows a search • identifies documents that most likely link both search terms	• mercury NEAR bioaccumulation
( )	The terms inside the brackets are to be searched for first.	• narrows a search • can be used with other search operators (e.g., AND, OR, and NEAR) • useful for phrases and associations between phrases	• (global warming) NEAR (arctic food chains)
site:	Search within a defined site.	• narrows a search • searches within a site using a specific search term or terms	• quirks site:cbc.ca • "quirks and quarks" site:cbc.ca
domain:	Search for websites from a certain domain or place of origin.	• narrows a search • obtains information from locations that may have distinct or unique perspectives • adds specific search terms to further target search	• domain:uk • other domains: – .com (commercial) – .org (organizations) – .ca (Canada) – .uk (United Kingdom) – .gov (government)
url:	Search for websites with specific words or terms in their title.	• narrows a search • uses synonyms as other search terms as they may appear in the url name for sites on the subject	url:WHMIS
link:	Find sites that have links to a specific site or search term.	• expands a search • useful for identifying sites with a related purpose • substantiates information or opinions expressed on one site	• link:policynut.com • link:"quirks and quarks"
title:	Identify pages that contain the search term in their title.	• narrows a search • identifies specific information within a general search	• title:mercury • title:bioaccumulation canada AND mercury

10 Reading for Understanding

An essential skill of science is to be able to read for understanding. Information must be processed before it can be made useful. Useful information might confirm or add support to ideas you already have by expanding on ideas or adding new arguments; or it might present alternate data or points of view you must consider before making your final decision. Since you use information to demonstrate your level of understanding, it is essential that you develop skills to read for understanding.

Points to Remember

- Reading is an active process. You must be thinking while you are reading.
- You need to break the information down into smaller bits and re-organize it.
- Try recalling what you already know about the topic before you start reading.
- Reading for understanding often requires multiple readings of the same document. Although it is not a quick process, it is thorough and efficient.
- Reading for understanding is a skill. With practice, you get better and quicker at it.

Note: The method described in this section may be similar to strategies you have already heard about or used. For example, one technique called SQ3R may have been introduced to you in other courses. If you already use a method to improve your level of reading for understanding, read this section over to see if there are any new aspects you can apply.

Steps to Follow

step 1: Prepare a table summarizing what you already know about the topic.

step 2: Skim through the reading to get a general idea of what the author is trying to communicate.

Pay attention to titles and subtitles, opening paragraphs, illustrations, conclusions, and vocabulary.

Rationale:
- organizes the major points being presented
- often contains summaries or overviews
- often restates the major points being made
- allows you to look up the meaning of unfamiliar words (Are they important to what is being said?)

At this point, identify any questions you have. Then use the information in the document to find answers to these questions before going on to the next step.

step 3: Thoroughly read the document with the conclusion in mind.

Pay attention to information used to support the conclusion.

Rationale: enables you to identify how the author connects the information presented (facts, data, opinions, etc.) to the conclusions made

step 4: Does the information agree, disagree, expand, or present other perspectives on what you already know? If it is useful information, add it to a new column in your table.

Pay attention to information and conclusions.

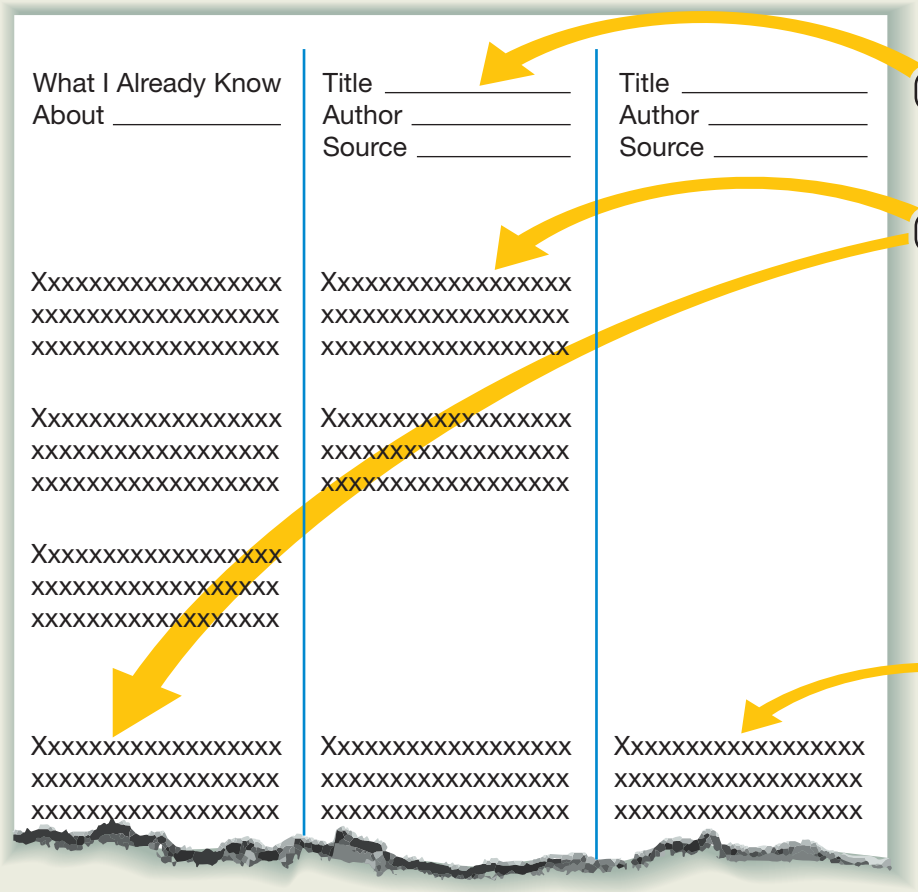
Rationale:
- enables you to organize and incorporate the new information into what you already know to deepen and strengthen your level of understanding
- helps you identify areas where your level of understanding is weak and where further information is needed

Here's what your chart might look like as you read for understanding.

Step 1:
Divide a page into three columns. Title the first column "What I Already Know About…"; and list the major points you already know.

Step 2:
Skim through the first document. Focus on titles, subtitles, illustrations, and new vocabulary, as well as the opening and closing paragraphs.

Step 3:
Thoroughly read the first document with the conclusion in mind.



Step 4:

A Write the title, author, and source of the first article.

B Place information from the document that agrees, disagrees, expands on, or presents other perspectives to the points you have already listed. Align the information with the same points beside each other in the columns.

Step 5:
Repeat steps 2, 3, and 4 with the other documents collected in your research.

11 Citing Sources of Information

The research you undertake leads you to sources that contain information about a topic. Although the information contained in sources is vital to the completion of your assignment, your performance and level of understanding is determined by how you connect and develop the ideas and facts contained in the information. A poorly completed assignment simply states or lists a great deal of information on a topic; it does not demonstrate that the writer spent the time to understand, explain, and connect the information into ideas in his or her own way. Any information collected by other people, or ideas that come from what others have written, must be acknowledged in a bibliography or a list of references.

The following table provides sample formats for citing important information or ideas you have collected in your research and have used in your own writing.

Source of Information	Example of Appropriate Format
Books	
with one author	Burlingame, R. Scientists Behind the Inventors. New York: Avon Books, 1960.
with more than one author	Black, P., C. Harrison, C. Lee, B. Marshall, and D. William. Assessment for Learning. Maidenhead, Berkshire: Open University Press, 2003.
Print Articles	
from a magazine	Dewar, E. "Nuclear Resurrection." Canadian Geographic, 125 (3). May/June 2005: 68–84.
from a journal	Pearson, E. "Weekly Molecules: A Cure for the 8:30 a.m. Blues." Journal of Chemical Education, 82 (6). 2005: 850.
from a newspaper	McLean, A. (2005 June 21). "River City Likely to Escape Deluge." The Edmonton Journal. 21 June 2005: A3.
Online Articles	
from an online journal	Williams, Kathryn R. "Don't Forget the Units!" Electronic version. Journal of Chemical Education, 76. 1999: 313. Internet. Retrieved from http://jchemed.chem.wisc.edu/Journal/Issues/1999/Mar/abs313.html 27 September 2005.
from an online newspaper	Hotz, R. "Brain Development Rate Linked to IQ." Los Angeles Times. 30 March 2006. Internet. Retrieved from http://www.latimes.com 31 March 2006.
full-text article obtained from a database	Linn, M. "Technology and Science Education: Starting Points, Research Programs, and Trends." International Journal of Science Education, 25 (6). 2003: 727. 32 p. Internet. Retrieved from EBSCO database 15 June 2005.
Websites	
	"Ecology of Grazed Ecosystems." The Macaulay Land Use Research Institute. Internet. 2005. Retrieved from http://www.mluri.sari.ac.uk/grazedecos 15 May 2005.
Government Documents	
	"Science 20 Program Outcomes." Alberta Education. June 2005.

A variety of websites exist that can provide additional information on the formats for other sources of information you may use.

12 Self-Assessment Rubric

Throughout your study in Science 20, your teacher will use rubrics or scoring guides to judge your work. Rubrics contain descriptions of what your work should look like in order to receive a particular mark. The descriptions listed in rubrics are useful for helping you to gain a better understanding of what is expected of you in your finished work.

A series of generic rubrics for Knowledge; Skills; and Science, Technology, and Society (STS) are shown on the back cover of the *Science Data Booklet* for your reference. Your teacher may also provide you with individual rubrics for assignments and activities you complete in this course.

Here is a rubric for self-assessment or for assessing the effort of other students in terms of their participation during group activities.

Score	Scoring Description
Standard of Excellence (4 marks)	The student effectively participates in discussions and activities, and encourages group members to get started and keep focused on the task. Practical solutions are offered to problems that arise, and the student actively seeks the input of others, initiating the sharing of ideas inside and outside of his or her group. The student is highly skilled in the use of technology and with the manipulatives used in the experiment or activity. The student routinely completes work that is required out of class time and often goes beyond requirements.
(3 marks)	The student contributes to discussions and activities and aids in keeping group members focused on the task. Practical solutions are offered to problems that arise, and the student listens to the input of others and shares ideas inside and outside of his or her group. The student is skilled in the use of technology and with the manipulatives used in the experiment or activity. The student routinely completes work that is required out of class time.
Acceptable Standard (2 marks)	The student participates in discussions and activities and usually focuses on the task. Some solutions may be offered to problems that arise, and the student usually listens to the input of others and is usually willing to share ideas inside and outside of his or her group. The student possesses adequate skill in the use of technology and with the manipulatives used in the experiment or activity. The student usually completes work that is required out of class time.
(1 mark)	The student doesn't contribute much to discussions and activities and has difficulty keeping focused on the task. Practical solutions are seldom offered to problems that arise, and the student does not listen to the input of others or share ideas inside and outside of his or her group. The student lacks skill (or doesn't participate) in the use of technology and with the manipulatives used in the experiment or activity. The student often does not complete work that is required out of class time.
(0 marks)	The assignment is not done at an appropriate level for a 20-level student.

13 Decision-Making Skills and Risk-Benefit Analysis

Many processes can be used to arrive at a decision. What is common to all these processes is the assessment of the possible impact that a solution will have before any action is taken. Problems do not occur in isolation; nor do they involve only one group of people. As a result, the perspectives of the groups of people involved must be considered. The decision-making model described in this section requires a number of steps to be completed.

step 1: Define the issue. Clearly state the problem, conflict, or issue, and state its source.

step 2: Make a table that identifies the groups of people involved (stakeholders), and identify their possible perspectives on the issue.

PERSPECTIVES AND THEIR FOCUS

Perspective	Focus
scientific	bases decisions on observation of natural phenomena, development of experiments to determine relationships, and theories
technological	advocates development of practical uses for scientific discoveries
ecological	bases decisions on concerns for environment and balance between biotic and abiotic factors within
economic	relates decisions to trade, industry, or money
political	bases decisions around actions of government or organizations involved with government that attempt to influence way a country is governed
legal	bases decisions on existing laws or their interpretation
ethical	bases decisions around accepted beliefs of group that acts to control its behaviour
societal	focuses on ways in which society functions and the way people interact and carry out their lives

SCORING RUBRIC FOR IDENTIFYING PERSPECTIVES

Score	Scoring Description
Standard of Excellence (4 marks)	The response demonstrates that at least three stakeholders have been identified and that a range of perspectives has been considered.
Acceptable Standard (2 marks)	The response demonstrates that more than one stakeholder has been identified and that more than one perspective was considered.

Note that this rubric, as well as the others shown in this section, are concise rubrics. Scores of 3, 1, and 0 can be inferred by the criteria for the scores of 4 and 2.

step 3: Research the issue. Conduct research to collect and assess information for all the perspectives of the stakeholders you identified. Assemble the relevant information as points in a table.

SCORING RUBRIC FOR RESEARCHING THE ISSUE

Score	Scoring Description
Standard of Excellence (4 marks)	The response demonstrates that at least four searches using different combinations of key words have been attempted and that a rich base of information related to the issue was developed.
Acceptable Standard (2 marks)	The response demonstrates more than one search attempt was made and that some information related to the issue was discovered.

step 4: Analyze the issue. Identify the risks and benefits of all the information relevant to the problem or issue. Determine a possible reaction for each of the stakeholder groups to the information you collected.

SCORING RUBRIC FOR RISK-BENEFIT ANALYSIS AND REACTIONS OF THE STAKEHOLDERS

Score	Scoring Description
Standard of Excellence (4 marks)	The response lists a variety of risks and benefits. The items listed demonstrate that thorough research was conducted by the student. The response demonstrates that most of the risks and benefits have been cited as the student considered the question from the point of view of at least three stakeholders.
Acceptable Standard (2 marks)	The response lists more than one entry in each column. The items listed demonstrate that some research was conducted by the student. The response demonstrates that some of the risks and benefits have been cited as the student considered the question from the point of view of more than one stakeholder.

step 5: Take a stand and defend your position. Review your analysis, and clearly state and defend a logical solution or an action to take.

SCORING RUBRIC FOR TAKING A STAND AND DEFENDING YOUR POSITION

Score	Scoring Description
Standard of Excellence (4 marks)	The response indicates that the student has taken a clear position that is supported by the body of the research and has considered the question from more than one point of view.
Acceptable Standard (2 marks)	The response indicates that the student has taken a position that is supported by some of the research.

step 6: Evaluate. Share your decision with others. How do their decisions differ from yours? How do the arguments differ? What have you learned from listening to their decisions? Comment on how their decisions have affected yours. Do the decisions shared completely address the initial question posed?

SCORING RUBRIC FOR EVALUATING

Score	Scoring Description
Standard of Excellence (4 marks)	The response indicates that the student considered the positions of other students and that these alternative viewpoints have each been addressed.
Acceptable Standard (2 marks)	The response indicates that the student considered the position of at least one other student and that this alternative viewpoint has been addressed.

14 Mathematics and Science Directing Words

When you receive an assignment to complete, the first question you will probably ask yourself will be, "What am I being asked to do?"

To determine what you need to do, you must identify and have a correct understanding of the directing words used in the assignment instructions. Directing words are terms that describe the actions you will need to take to complete the task.

The list of mathematics and science directing words given are used in questions, activities, and laboratory exercises throughout this textbook. This same list is used in examination questions—including the diploma examinations in mathematics and science—to provide you with specific directions of what to do in completing your response. It is important that you become familiar with the meanings of these words so you can increase the accuracy and efficiency of your work.

Algebraically

Use mathematical procedures that involve letters or symbols to represent numbers.

Analyze

Make a mathematical, chemical, or methodical examination of parts of the whole; determine the nature, proportion, function, interrelationship, etc., of those parts.

Compare

Examine the character or qualities of two things by providing characteristics of both that point out their similarities and differences.

Conclude

State a logical end based on reasoning and/or evidence.

Contrast/Distinguish

Point out the differences between two things that have similar or comparable natures.

Criticize

Point out the demerits of an item or issue.

Define

Provide the essential qualities or meaning of a word or concept; make distinct and clear by marking out the limits.

Describe

Give a written account or represent the characteristics of something by a figure, model, or picture.

Design/Plan

Construct a plan (e.g., a detailed sequence of actions for a specific purpose).

Determine

Find a solution, to a specified degree of accuracy, to a problem by showing appropriate formulas, procedures, and calculations.

Enumerate

Specify one by one or list in concise form according to some order.

Evaluate

Give the significance or worth of something by identifying the good and bad points or advantages and disadvantages.

Explain

Make clear what is not immediately obvious or entirely known; give the cause of or reason for; make known in detail.

Graphically

Use a drawing produced electronically or by hand that shows a relation between certain sets of numbers.

How

Show in what manner or way and with what meaning.

Hypothesize

Form a tentative proposition intended as a possible explanation for an observed phenomenon (e.g., a possible cause for a specific effect). The proposition should be logically and/or empirically testable.

Identify

Recognize and select as having the characteristics of something.

Illustrate

Make clear by giving an example. The form of the example must be specified in the question (e.g., word descriptions, sketches, and diagrams).

Infer

Form a generalization from sample data; arrive at a conclusion by reasoning from evidence.

Interpret

Tell the meaning of something; present information in a new form that adds meaning to the original data.

Justify/Show How

Show reasons for or give facts that support a position.

Model

Find a model that effectively represents a situation. (In mathematics, a model of a situation is a pattern that is supposed to represent or set a standard for a real situation.)

Outline

Provide the essential parts of something in an organized fashion. The form of the outline must be specified in the question (e.g., list, flowchart, and concept map).

Predict

Tell in advance on the basis of empirical evidence and/or logic.

Prove

Establish the validity of a statement for the general case by providing factual evidence or a logical argument.

Relate

Show a logical or causal connection between things.

Sketch

Provide a drawing that represents the key features of an object or graph.

Solve

Provide a solution for the problem (e.g., an explanation in words and/or numbers).

Summarize

Give a brief account of the main points.

Trace

Provide a step-by-step description of the development.

Verify

Establish the truth of a statement by substitution for a particular case or by geometric comparison.

Why

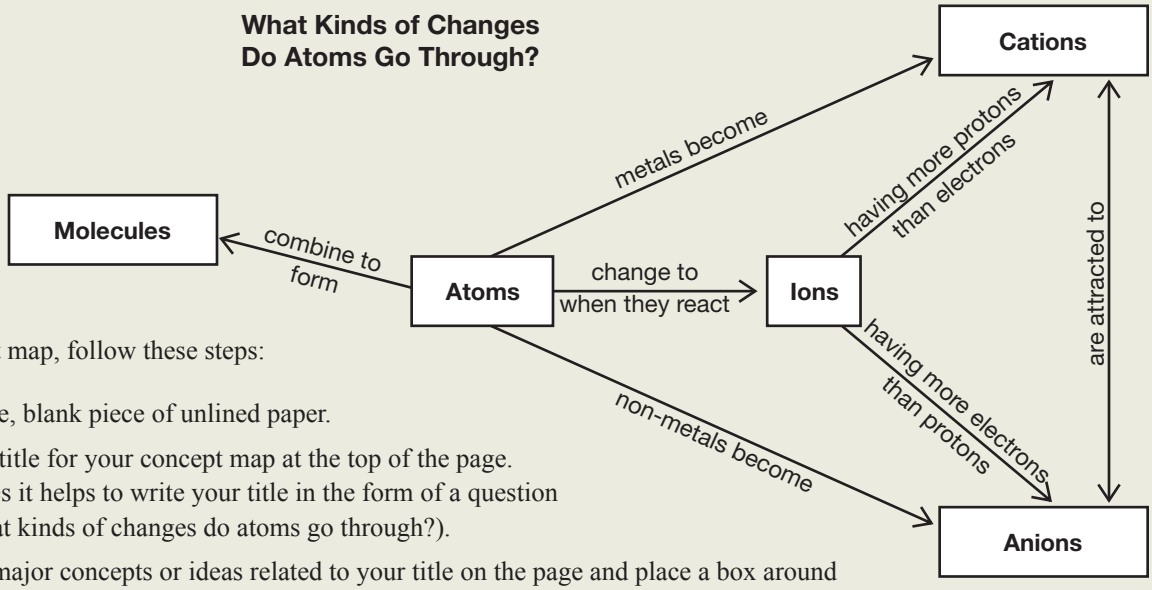
Show the cause, reason, or purpose.

15 Summarize Your Learning Activities

At the end of a chapter, unit, or any substantial amount of material, it is important to identify the most important concepts and determine why they are important and how they relate to each other. There are six options listed. They are intended to help you review, connect, and associate the concepts and information you studied in unique ways that will engage your thinking and promote higher levels of understanding. Your teacher may choose to assess your work. So, use the rubric given on page 553 to guide your efforts and to assess your work before its completion.

Drawing a Concept Map or Web Diagram

Here's a challenge for you. Show yourself how much you've learned by using a concept map. Creating a concept map allows you to turn on the other parts of your brain to see how the concepts are organized, how the concepts can be interconnected to each other, and how to interpret large amounts of information in a new way.



To draw a concept map, follow these steps:

step 1: Get a large, blank piece of unlined paper.

step 2: Write the title for your concept map at the top of the page. Sometimes it helps to write your title in the form of a question (e.g., What kinds of changes do atoms go through?).

step 3: Print the major concepts or ideas related to your title on the page and place a box around them. Don't worry about where you place them, just get those important ideas down on the page.

step 4: Identify boxes that contain related concepts. If they are related, connect them with a line.

step 5: Using a maximum of five words, describe how the two concepts are related. Print this linking statement on the line. (It may help to use an arrow rather than a line so that your linking statements read easier; for example, Atoms *combine to form* Molecules.

step 6: Try connecting each concept on your map as many times as possible.

step 7: Place new concepts on your map when needed. You may be surprised just how much you remember from the lessons in the chapter, or other parts of the course, and how they relate to each other. Don't forget to include examples of things you saw or did that connect to the concepts as well.

A concept map is never finished; so don't be afraid to come back to it from time to time to read it, to remember what you've learned, and to revise and add to it as you learn more.

Keep it creative! You can use colours to organize the information on your concept map to show the organization of the concepts around related themes. Make lots of links between concepts; they show how well you understand how the concepts are related.

Add in personal events or examples you can think of that relate to the concepts. These might be observations from labs and demonstrations and examples from what you have read and seen.

Creating a Point-Form Summary

Summaries are an effective way to review the notes you have made for the information from articles or textbooks. Good summaries include key terms, and they briefly describe why the key terms are important.

Lesson C1.5: Point-Form Summary

Key Term	Why Term Is Important
radioactivity	• Atoms that decay change from one type of atom to another. • Atoms that decay are present in fossils. • Comparing the number of atoms that have decayed to those that have not decayed leads to the parent-daughter material ratio. • The ratio of parent-daughter material indicates the number of half-lives that have elapsed.

Writing a Story Using Key Terms and Concepts

Let your imagination flow. Think of a situation that would provide a great opportunity for you to use your knowledge of the concepts in the chapter to tell a scientifically accurate story. It could be a personal event, or you may want to base your story on an extension of one of the situations mentioned in the chapter.

Creating a Colourful Poster

Be visual in demonstrating what you've learned. Portray not only the main knowledge concepts, but other important aspects related to the topic, such as political, economic, or social issues and technologies. Display these aspects in a way that invites people to look at the poster and see what you have learned.

Building a Model

Sometimes the best way to explain all the parts or events occurring in a situation is with a model. Models provide a chance to identify the important parts or events and show how they contributed to the overall effect or end result.

Writing a Script for a Skit or a Mock News Report

If your news report is to make it onto the nightly newscast, it has to get across all the essential information as clearly, accurately, and briefly as possible. Remember the 5 Ws of journalism: What happened? Where did it happen? When did it happen? Why did it happen? Who was affected?

Write your news report to answer the 5 Ws for a situation that relates to the chapter information. Think of who should be interviewed to provide insight into the story (e.g., experts, observers, and people affected). Remember to include the key terms and concepts and their correct interpretation in your script.

SCORING RUBRIC FOR SUMMARIZING YOUR LEARNING ACTIVITIES

Score	Scoring Description
Standard of Excellence (4 marks)	The sample of work is well organized and addresses many major points. Relevant scientific, technological, and/or societal concepts and examples are identified and interrelationships are explicit. The descriptions and/or explanations of these concepts are correct, well organized, and reflect thorough understanding and logical consistency of thought. The student makes effective use of scientific vocabulary where appropriate. When appropriate, suitable metaphors, similes, diagrams, and/or sketches are used to illustrate descriptions and/or explanations.
Acceptable Standard (2 marks)	The sample of work addresses most major points. Relevant scientific, technological, and/or societal concepts and examples are identified, and interrelationships are shown. The descriptions and/or explanations of concepts may be disorganized but demonstrate correct understanding. The student inconsistently uses appropriate scientific vocabulary. Diagrams and sketches may demonstrate a correct, but sketchy, level of understanding.

Periodic Table of Elements

1	2	3	4	5	6	7	8	9
1 H hydrogen 1.01 H^+ hydrogen								
3 Li lithium 6.94 Li^+ lithium	4 Be beryllium 9.01 Be^{2+} beryllium							
11 Na sodium 22.99 Na^+ sodium	12 Mg magnesium 24.31 Mg^{2+} magnesium							
19 K potassium 39.10 K^+ potassium	20 Ca calcium 40.08 Ca^{2+} calcium	21 Sc scandium 44.96 Sc^{3+} scandium	22 Ti titanium 47.87 Ti^{4+} titanium(IV) Ti^{3+} titanium(III)	23 V vanadium 50.94 V^{5+} vanadium(V) V^{4+} vanadium(IV)	24 Cr chromium 52.00 Cr^{3+} chromium(III) Cr^{2+} chromium(II)	25 Mn manganese 54.94 Mn^{2+} manganese(II) Mn^{4+} manganese(IV)	26 Fe iron 55.85 Fe^{3+} iron(III) Fe^{2+} iron(II)	27 Co cobalt 58.93 Co^{2+} cobalt(II) Co^{3+} cobalt(III)
37 Rb rubidium 85.47 Rb^+ rubidium	38 Sr strontium 87.62 Sr^{2+} strontium	39 Y yttrium 88.91 Y^{3+} yttrium	40 Zr zirconium 91.22 Zr^{4+} zirconium	41 Nb niobium 92.91 Nb^{5+} niobium(V) Nb^{3+} niobium(III)	42 Mo molybdenum 95.94 Mo^{6+} molybdenum	43 Tc technetium (98) Tc^{7+} technetium	44 Ru ruthenium 101.07 Ru^{3+} ruthenium(III) Ru^{4+} ruthenium(IV)	45 Rh rhodium 102.91 Rh^{3+} rhodium
55 Cs cesium 132.91 Cs^+ cesium	56 Ba barium 137.33 Ba^{2+} barium	57-71	72 Hf hafnium 178.49 Hf^{4+} hafnium	73 Ta tantalum 180.95 Ta^{5+} tantalum	74 W tungsten 183.84 W^{6+} tungsten	75 Re rhenium 186.21 Re^{7+} rhenium	76 Os osmium 190.23 Os^{4+} osmium	77 Ir iridium 192.22 Ir^{4+} iridium
87 Fr francium (223) Fr^+ francium	88 Ra radium (226) Ra^{2+} radium	89-103	104 Rf rutherfordium (266)	105 Db dubnium (262)	106 Sg seaborgium (266)	107 Bh bohrium (264)	108 Hs hassium (277)	109 Mt meitnerium (268)

Note: The legend at the right denotes the physical state of the elements at 101.325 kPa and 298.15 K (25°C).

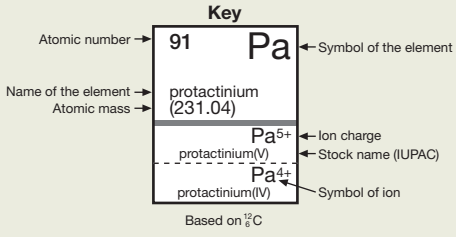
Legend for the elements

Solid	Liquid	Gas	Seldom forms ions

Table of Polyatomic Ions and Elements

Polyatomic ions									
acetate	CH_3COO^-	hydrogen carbonate	HCO_3^-	cyanide	CN^-	phosphate	PO_4^{3-}	sulfite	SO_3^{2-}
ammonium	NH_4^+	chlorate	ClO_3^-	hydroxide	OH^-	hydrogen phosphate	HPO_4^{2-}	hydrogen sulfide	HS^-
benzoate	$C_6H_5COO^-$	hypochlorite	ClO^-	nitrate	NO_3^-	dihydrogen phosphate	$H_2PO_4^-$	hydrogen sulfate	HSO_4^-
borate	BO_3^{3-}	chromate	CrO_4^{2-}	nitrite	NO_2^-	silicate	SiO_3^{2-}	hydrogen sulfite	HSO_3^-
carbonate	CO_3^{2-}	dichromate	$Cr_2O_7^{2-}$	permanganate	MnO_4^-	sulfate	SO_4^{2-}		

Key



Most stable or common ion is listed above the dotted line
( ) indicates mass of the most stable isotope

57 La lanthanum 138.91 La^{3+} lanthanum	58 Ce cerium 140.12 Ce^{3+} cerium	59 Pr praseodymium 140.91 Pr^{3+} praseodymium	60 Nd neodymium 144.24 Nd^{3+} neodymium	61 Pm promethium (145) Pm^{3+} promethium	62 Sm samarium 150.36 Sm^{3+} samarium(III) Sm^{2+} samarium(II)
89 Ac actinium (277) Ac^{3+} actinium	90 Th thorium 232.04 Th^{4+} thorium	91 Pa protactinium 231.04 Pa^{5+} protactinium(V) Pa^{4+} protactinium(IV)	92 U uranium 283.03 U^{6+} uranium(VI) U^{4+} uranium(IV)	93 Np neptunium (237) Np^{5+} neptunium	94 Pu plutonium (244) Pu^{4+} plutonium(IV) Pu^{6+} plutonium(VI)

References: Lide, D.R. 2005. *CRC Handbook of Chemistry and Physics*. 86th Edition: 2005–2006, Boca Raton, FL, CRC Press

10	11	12	13	14	15	16	17	18
							1 H hydrogen 1.01	2 He helium 4.00
							H^- hydride	He helium
			5 B boron 10.81	6 C carbon 12.01	7 N nitrogen 14.01	8 O oxygen 16.00	9 F fluorine 19.00	10 Ne neon 20.18
			B boron	C carbon	N^{3-} nitride	O^{2-} oxide	F^- fluorine	Ne neon
			13 Al aluminium 26.98	14 Si silicon 28.09	15 P phosphorus 30.97	16 S sulfur 32.07	17 Cl chlorine 35.45	18 Ar argon 39.95
			Al^{3+} aluminium	Si silicon	P^{3-} phosphide	S^{2-} sulfide	Cl^- chloride	Ar argon
28 Ni nickel 58.69	29 Cu copper 63.55	30 Zn zinc 65.41	31 Ga gallium 69.72	32 Ge germanium 72.64	33 As arsenic 74.92	34 Se selenium 78.96	35 Br bromine 79.90	36 Kr krypton 83.80
Ni^{2+} nickel(II) Ni^{3+} nickel(III)	Cu^{2+} copper(II) Cu^+ copper(I)	Zn^{2+} zinc	Ga^{3+} gallium	Ge^{4+} germanium	As^{3-} arsenide	Se^{2-} selenide	Br^- bromide	Kr krypton
46 Pd palladium 106.42	47 Ag silver 107.87	48 Cd cadmium 112.41	49 In indium 114.82	50 Sn tin 118.71	51 Sb antimony 121.76	52 Te tellurium 127.60	53 I iodine 126.90	54 Xe xenon 131.30
Pd^{2+} palladium(II) Pd^{3+} palladium(IV)	Ag^+ silver	Cd^{2+} cadmium	In^{3+} indium	Sn^{4+} tin(IV) Sn^{2+} tin(II)	Sb^{3+} antimony(III) Sb^{5+} antimony(V)	Te^{2-} telluride	I^- iodide	Xe xenon
78 Pt platinum 195.08	79 Au gold 196.97	80 Hg mercury 200.59	81 Tl thallium 204.38	82 Pb lead 207.2*	83 Bi bismuth 208.98	84 Po polonium (209)	85 At astatine (210)	86 Rn radon (222)
Pt^{4+} platinum(IV) Pt^{2+} platinum(II)	Au^{3+} gold(III) Au^+ gold(I)	Hg^{2+} mercury(II) Hg^+ mercury(I)	Tl^+ thallium(I) Tl^{3+} thallium(III)	Pb^{2+} lead(II) Pb^{4+} lead(IV)	Bi^{3+} bismuth(III) Bi^{5+} bismuth(V)	Po^{2+} polonium(II) Po^{4+} polonium(IV)	At^- astatide	Rn radon
110 Ds darmstadtium (271)	111 Rg roentgenium (272)	112 Uub ununbium (285)		114 Uuq ununquadium (289)		116 Uuh ununhexium (289)		

Elements

astatine	At_2	iodine	I_2
bromine	Br_2	nitrogen	N_2
chlorine	Cl_2	oxygen	O_2
fluorine	F_2	phosphorus	P_4
hydrogen	H_2	sulfur	S_8

* The isotopic mix of naturally occuring lead is more variable than other elements, preventing precision to greater than tenths of a gram per mole.

63 Eu europium 151.96	64 Gd gadolinium 157.25	65 Tb terbium 158.93	66 Dy dysprosium 162.50	67 Ho holmium 164.93	68 Er erbium 167.26	69 Tm thulium 168.93	70 Yb ytterbium 173.04	71 Lu lutetium 174.97
Eu^{3+} europium(III) Eu^{2+} europium(II)	Gd^{3+} gadolinium	Tb^{3+} terbium	Dy^{3+} dysprosium	Ho^{3+} holmium	Er^{3+} erbium	Tm^{3+} thulium	Yb^{3+} ytterbium(III) Yb^{2+} ytterbium(II)	Lu^{3+} lutetium
95 Am americium (243)	96 Cm curium (247)	97 Bk berkelium (247)	98 Cf californium (251)	99 Es einsteinium (252)	100 Fm fermium (257)	101 Md mendelevium (258)	102 No nobelium (259)	103 Lr lawrencium (262)
Am^{3+} americium(III) Am^{4+} americium(IV)	Cm^{3+} curium	Bk^{3+} berkelium(III) Bk^{4+} berkelium(IV)	Cf^{3+} californium	Es^{3+} einsteinium	Fm^{3+} fermium	Md^{2+} mendelevium(II) Md^{3+} mendelevium(III)	No^{2+} nobelium(II) No^{3+} nobelium(III)	Lr^{3+} lawrencium

IUPAC Periodic Table of the Elements. 2005. http://www.iupac.org/reports/periodic_table/index.html

Electrochemistry: Activity Series

Activity Series for 1.0 mol/L Solution at 25°C and 101.325 kpa

Increasing strength of oxidizing agent

Reduction Half-Reaction				
$Au^{3+}(aq)$	+	$3e^-$	Æ	Au(s)
$Hg^{2+}(aq)$	+	$2e^-$	Æ	Hg(□)
$Ag^{+}(aq)$	+	e^-	Æ	Ag(s)
$Cu^{2+}(aq)$	+	$2e^-$	Æ	Cu(s)
$2\ H^{+}(aq)$	+	$2e^-$	Æ	$H_2(g)$
$Pb^{2+}(aq)$	+	$2e^-$	Æ	Pb(s)
$Sn^{2+}(aq)$	+	$2e^-$	Æ	Sn(s)
$Ni^{2+}(aq)$	+	$2e^-$	Æ	Ni(s)
$Cd^{2+}(aq)$	+	$2e^-$	Æ	Cd(s)
$Fe^{2+}(aq)$	+	$2e^-$	Æ	Fe(s)
$Zn^{2+}(aq)$	+	$2e^-$	Æ	Zn(s)
$Cr^{2+}(aq)$	+	$2e^-$	Æ	Cr(s)
$Al^{3+}(aq)$	+	$3e^-$	Æ	Al(s)
$Mg^{2+}(aq)$	+	$2e^-$	Æ	Mg(s)
$Na^{+}(aq)$	+	e^-	Æ	Na(s)
$Ca^{2+}(aq)$	+	$2e^-$	Æ	Ca(s)
$Li^{+}(aq)$	+	e^-	Æ	Li(s)

Increasing strength of reducing agent

Organic and Molecular Chemistry: Nomenclature

Homologous Series of Alkanes and 25°C and 101.325 kPa

Name*	Formula	Name*	Formula
methane	$CH_4(g)$	hexane	$C_6H_{14}(l)$
ethane	$C_2H_6(g)$	heptane	$C_7H_{16}(l)$
propane	$C_3H_8(g)$	octane	$C_8H_{18}(l)$
butane	$C_4H_{10}(g)$	nonane	$C_9H_{20}(l)$
pentane	$C_5H_{12}(l)$	decane	$C_{10}H_{22}(l)$

*Note: Italics are for emphasis of organic prefixes.

Prefixes for Molecular Compounds

1 = mono-	6 = hexa-
2 = di-	7 = hepta-
3 = tri-	8 = octa-
4 = tetra-	9 = ennea- (nona-)
5 = penta-	10 = deca-

General Formulas

Type of Hydrocarbon	Formula n = number of carbon atoms
alkane	$C_nH_{(2n+2)}$
alkene	$C_nH_{(2n)}$
alkyne	$C_nH_{(2n-2)}$

Types of Reactions

Simple Composition or Formation
element + element Æ compound

Simple Decomposition
compound Æ element + element

Single Replacement
compound + element Æ compound + new element

Double Replacement
compound + compound Æ new compound + new compound

Hydrocarbon Combustion Reaction
hydrocarbon + oxygen Æ carbon dioxide + water

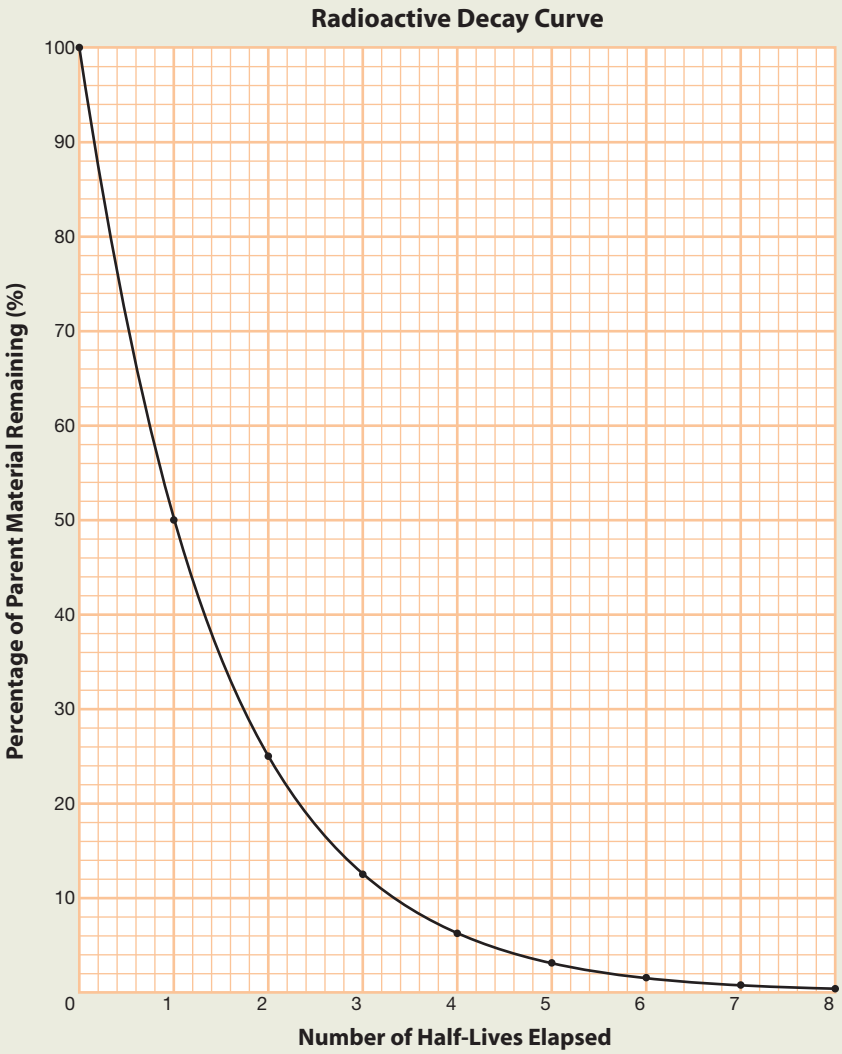
Addition Reactions
alkene + halogen Æ alkane + functional group
alkyne + halogen Æ alkene + functional group

Substitution Reaction
alkane + halogen Æ alkane + functional group

Geological Time Scale

Millions of Years Ago	Era	Period	Epoch
1.7	CENOZOIC	Quaternary	Holocene / Pleistocene
		Tertiary	
65	MESOZOIC	Cretaceous	
140		Jurassic	
210		Triassic	
250	PALEOZOIC	Permian	
290		Carboniferous	
360		Devonian	
410		Silurian	
440		Ordovician	
500		Cambrian	
590	PRECAMBRIAN		
2500			
4000			
4500			

Elements for Radioactive Dating

Radioisotope (Parent Nuclide)		Decay Nuclide (Daughter Nuclide)		Approximate Half-Life (annum, a)
carbon-14	$^{14}_{6}C$	nitrogen-14	$^{14}_{7}N$	5.72×10^{3}
potassium-40	$^{40}_{19}K$	argon-40	$^{40}_{18}Ar$	1.26×10^{9}
rubidium-87	$^{87}_{37}Rb$	strontium-87	$^{87}_{38}Sr$	4.88×10^{10}
uranium-235	$^{235}_{92}U$	lead-207	$^{207}_{82}Pb$	7.04×10^{8}
uranium-238	$^{238}_{92}U$	lead-206	$^{206}_{82}Pb$	4.47×10^{9}

Radioactive Decay Curve